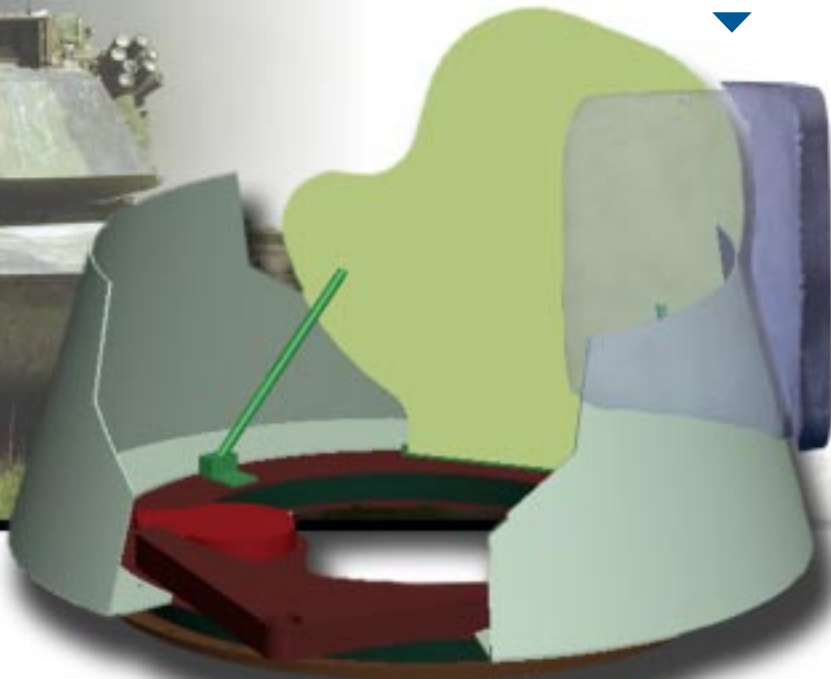


# Increasing the Odds



Abrams M1, the world's most powerful tank, is defended by INL-produced heavy armor.

INL is developing a prototype of a lightweight turret apron HMMWV cab, integrating INL's conformal SiC tiles into a composite armor system for IED and level IV ballistic threats.



## Survivability

**Full spectrum capabilities from threat analysis and R&D to rapid response design and manufacturing**

Idaho National Laboratory



The Idaho National Laboratory produces the heavy armor that helps make the U.S. Army Abrams Tank the world's best armored vehicle. The INL also provides a full spectrum of survivability services to the Department of Defense, the Intelligence Community and other government agencies including threat analysis, systems engineering, prototyping, design and special process manufacturing.

As a Department of Energy multi-program laboratory, the INL conducts a broad range of basic and applied research focusing on comprehensive survivability

solutions to meet the ever changing threat.

We provide solutions that capitalize on the laboratory's superlative capabilities in materials engineering, integrated design and award-winning manufacturing processes.

The INL's thorough and exacting approach to project execution is demonstrated across its spectrum of services. While supporting DoD in a technology roadmapping effort for the Stryker Program, the laboratory's engineers created a new set of tools required to predict technology needs and the risk associated with

the needs – the knowledge needed for critical decisions in the acquisition planning process.

The INL, with its award-winning R&D, practical engineering and proven manufacturing roles, offers the Department of Defense a focal point to help address the complex issues of active and passive armor defense.

**INL is the place to come for materials R&D, rapid prototypes, limited-run production; providing creative and complete technology solutions.**



INL is working to improve the clarity of a pressureless sintered form of Aluminum Oxynitride (AlON), as a transparent armor, which would result in reduced production costs, while maintaining survivability levels of existing AlON products.

## Current Research

### Material Bonding

INL scientists are investigating several rapid in-situ joining methods. Researchers are using fine mesh of high electrical resistance to initiate a self-sustaining, exothermic reaction in solder to bond SiC and Ti alloy.

Additionally, they are testing a pulsed induction method, in which a specially designed induction coil is energized by an appropriate frequency to “couple” only with the braze materials in the joint area, thus providing rapid, localized RF-heating of the specific braze filler compound.

### Titanium

Our scientists are investigating and developing a more effective fabrication process for thin Ti-10-2-3 plate stock. The resultant material will be evaluated as a potential solution to meet the threat level requirement of light-armored combat and tactical vehicles. To support this research, they are developing a more durable friction stir weld tool to withstand the rigors of joining hard titanium alloys.

### Encapsulation

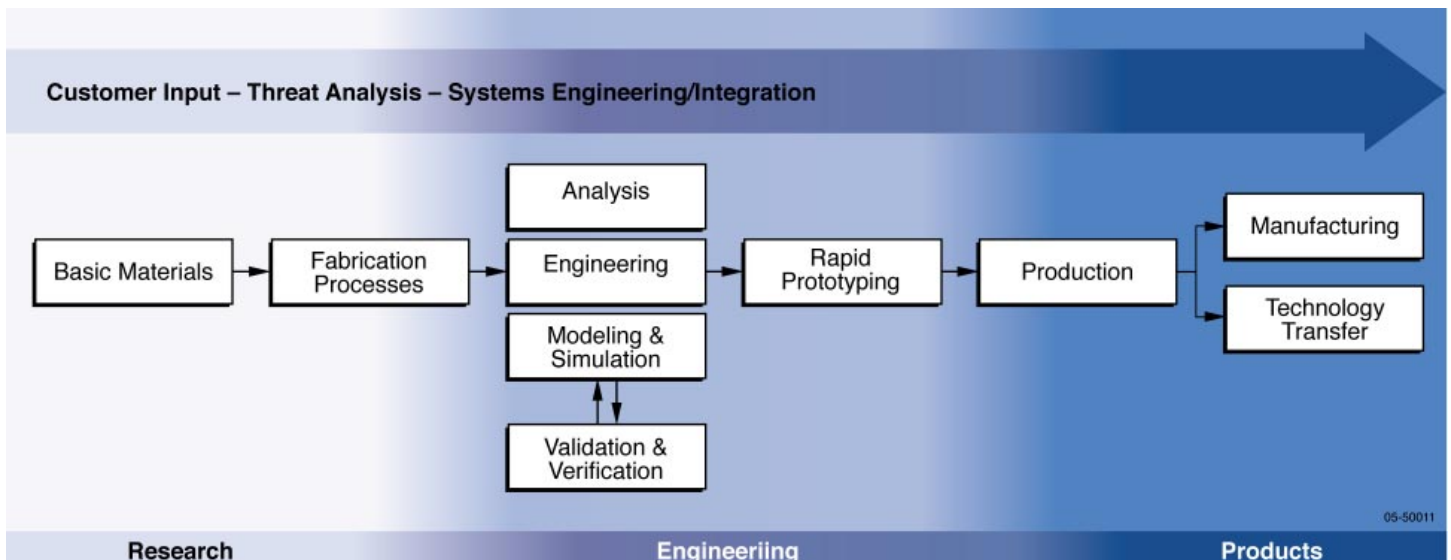
INL scientists are investigating spray-form processes to manufacture metallic-based alloy materials, such as aluminum, steel or titanium to determine the appropriate material and process

for encapsulation of ceramic armor tiles. This is done to improve the multi-hit capability of ceramic armor tiles. The low-cost, pressureless sintered alpha-SiC tiles used in the encapsulation were developed in collaboration with our commercial partner, Superior Graphite Corp. The researchers are also developing the spray-form encapsulation of complex conformal armor tiles and will evaluate ballistic performance of such systems. Such encapsulated ceramic structures are designed to be part of the next-generation of light to medium weight combat armor systems.

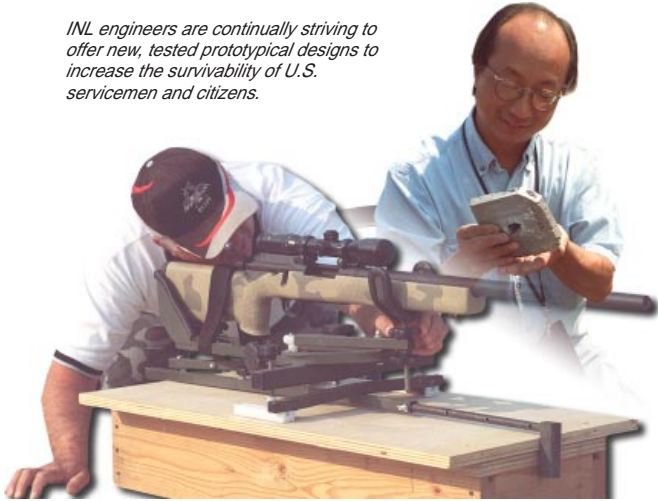
### Laboratory-Funded Research

The INL is sponsoring several research projects whose success could reduce the cost of production and/or increase performance of existing armor materials. These programs include low-cost transient liquid phase sintered aluminum oxynitride, a transparent armor, and SiC/TiB<sub>2</sub>.

## INL Survivability Spectrum



*INL engineers are continually striving to offer new, tested prototypical designs to increase the survivability of U.S. servicemen and citizens.*



### **Development and Testing**

The INL has unmatched capabilities in armor material development, systems design and ballistic testing. We also work in collaboration with private industry and other government agencies to turn new processes into real prototypes.

#### **Materials Laboratory**

We have a full range of material testing capabilities. The tests range from standard, quasi-static tests to high-strain, rate-split Hopkinson pressure-bar testing.

We can conduct tests with an advanced high-speed magnetic flyer plate impact tester. It is supported by laser Moire interferometry and high-speed cameras to record shock wave propagation phenomena during impact.

We have extensive analytical and metallurgical laboratory capabilities, such as scanning and tunneling electron microscopy, X-ray diffraction and Auger electron examination.

#### **Live-Fire Test Range**

We have an on-site indoor, mil-spec compliant test range for testing up to .30 cal. armor-piercing (AP) rounds, and an outdoor range for .50 cal. AP rounds. We will soon be adding the capability to test for 14.5 and 20 mm threats. Additionally, we can perform live-fire testing with explosive devices, RPGs, explo-

sively-formed projectiles and shape charges.

#### **Modeling and Simulation**

We have the high performance computers needed for modeling and simulation of impact phenomena in detail. Our team has many years of experience in the use of advanced hydrodynamic computer codes, such as CTH, DYNA, EPIC and ZEUS for modeling the design and verification of armor systems. We are now adding ALEGRA to our library of codes, and are working on its validation to enhance functionality for our needs.

#### **Standards Development**

We are developing a ballistic protection standard for the Technical Support Working Group (TSWG) of the Department of Defense Combating Terrorism Technology Support Office. The project, sponsored by the Personal Protection subgroup of TSWG, is included in a larger standard for the design and testing of armored passenger vehicles.

#### **Flexible Manufacturing**

The INL maintains an unparalleled armor manufacturing facility with comprehensive capabilities including high temperature metal rolling and radioactive and non-radioactive materials processing. Our capabilities include the full range of product development and manufacturing skills for material process development to meet any armor, shielding and structural material requirements.

We process a wide range of materials for armor, shielding and structural applications with demonstrated capability to handle radioactive and non-radioactive, ferrous and non-ferrous metal alloys, and metal matrix composites.

With more than 20 years of experience, we can rely on a full complement of support personnel who can evaluate problems and develop the solutions specific to

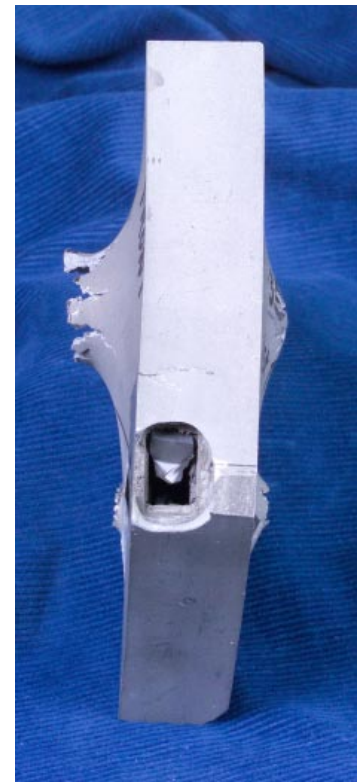
metal alloy and armor system development and production.

#### **Security**

Our secure facilities and cleared personnel support classified programs and comply with DOE and Department of Defense requirements for processing classified materials and information. A classified computer network is integrated into all operations, engineering and administrative areas.

#### **Experience**

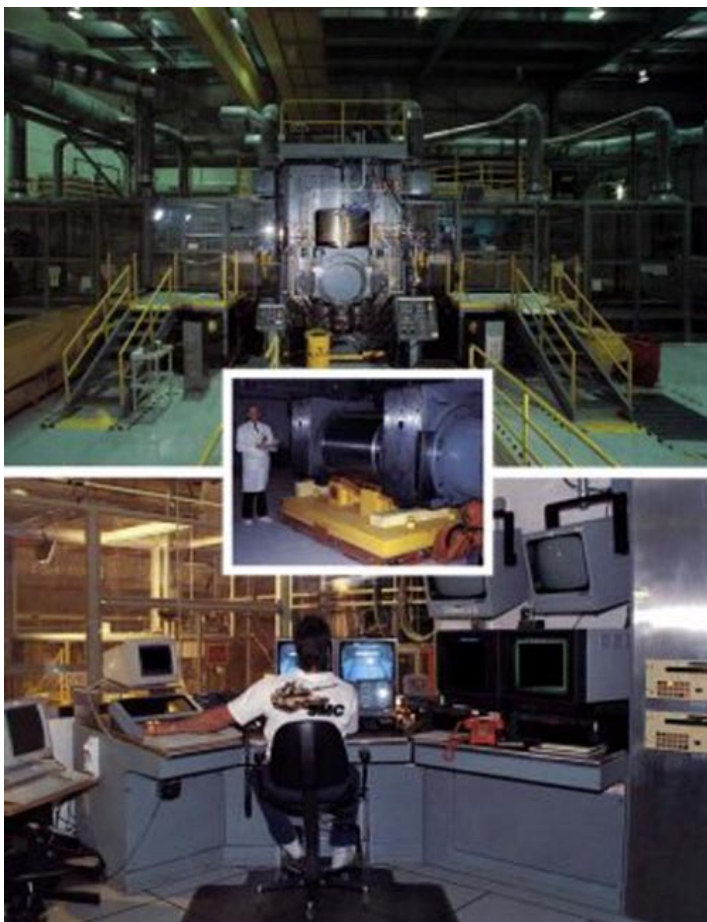
Our manufacturing statistics are perfect, with product delivery of 100 percent quality, 100 percent on time and zero cost overruns. Our safety record is remarkable, with over 2 million man-hours of operation, free of lost time injuries and accidents. In short, the record speaks for itself – INL facilities, workers and management thrive on the pursuit of excellence in armor and materials development and manufacture.



*INL researchers are developing an encapsulated ceramic armor to provide a multi-hit capability.*

Idaho National Laboratory





INL Specific Manufacturing Capability is a highly flexible armor production facility

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### Manufacturing Equipment and Services

Our plant is a fully integrated manufacturing facility with the capacity to roll and machine radioactive and non-radioactive, ferrous and non-ferrous metal alloys, and metal matrix composites. We have extensive experience in all areas of metal manufacturing and processing. Our metallurgical staff and production technicians are committed to working closely with our customers to achieve the expected results.

Sponsored by the  
U.S. Department of Energy



### Remote Material Handling

We have complete automated assembly with automated material retrieval, handling and inventory control. This has resulted in excellent safety records by virtually eliminating the need to manually handle heavy materials in most assembly applications.

### Rolling Mill

The rolling mill is a four-high, reversing hot mill, with 2,500 tons of separating force and 40-foot, fully enclosed ventilated entry and exit tables with the capability to roll up to 1 meter in width.

Recent upgrades provide integrated advanced electronic controls along with a renewal of the mill's mechanical components and a high through-put electric preheating furnace for non-radioactive materials processing.

### Annealing Furnaces

We use electric inert atmosphere furnaces to preheat ingots for hot or warm rolling. The electric furnaces operate at a maximum temperature of 1,200 degrees

Celsius. They are capable of heating several tons per hour to rolling temperature and can be used for product heat treatment.

### Fabrication Support Equipment

Our fabrication process is fully automated for processing plate and sheet products. The equipment includes various CO<sub>2</sub> lasers, a plasma cutting cell and a high pressure waterjet cutting cell. All processes are numerically controlled for automated processing. The Cincinnati CL707 Laser has a 2500 Watt chamber with an 8' by 20' cutting table. Both a contact and a noncontact head are used in our current cutting processes. Equipment controllers are directly linked to CAD systems for flexible manufacturing. Additionally, fabrication support equipment includes hydraulic shears, punches, press breaks and roll forming. Fabrication lines also have automated material handling systems for safe and efficient operations.



Annealing Furnaces